INTEGRATION PROJECT
EXPERT PANEL

Closeout Report for Panel Meeting Held April 25 – 27, 2001

Prepared by the Integration Project Expert Panel

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Table of Contents

Executive Summary

The ninth meeting of the Integration Project Expert Panel (IPEP) took place within the context of considerable uncertainty highlighted by the recent announcement of a reduced FY02 budget for DOE-EM, concern about the ability to maintain momentum on Integration Project (IP) tasks and vision, the forthcoming transfer of IP responsibility to Fluor Hanford in July 2002, and the future of "integration" at Hanford. While the FY02 budget process is not final, the current set of circumstances serves as a reminder that continued progress and success at Hanford depends in part on the nation's political agenda and changing priorities.

This panel meeting focused on three major IP areas: System Assessment Capability (SAC), Vadose Zone Characterization, and Science and Technology Projects (S&T). Prior to the meeting, there was also a one-day field trip attended by Dr. Wierenga and a number of stakeholders and regulators. Dr. Wierenga's observations and recommendations are included as part of this report.

Based on the information conveyed during the meeting and the roundtable discussions that took place, the IPEP concluded that notable progress has been made on many technical fronts by the IP. The concept of "integration" has been a very valuable stimulus to this progress and DOE-RL management is now demonstrating increased ownership of the concept of "integration" and its benefits.

The IPEP commends the IP and the related core projects for their accomplishments to date. The IP has strengthened its linkages both internally and externally at Hanford. Internally, the organizations involved in the IP have been linked physically through co-location and programmatically through shared objectives, while externally; the IP has contributed to wider acceptance of the integration concept by promoting changes in the governing culture. These actions pave the way for better coordination and more effective use of resources. These linkages and culture changes need to be further encouraged and preserved.

However, while it is clear that the IP has made great progress, many key efforts are not yet complete. These key efforts include agreement on end-states for the various contaminated areas providing sources of contamination to the subsurface, agreement on the definition of target protection levels in the Columbia River, and incorporation of cultural values of stakeholders into the decision making process for Hanford site cleanup.

In a roundtable discussion, several questions were addressed, among them "What, after several years of effort, have we perceived as the added benefits of 'integration'?" A summary of the benefits that were identified by the IPEP is provided below:

- Organizations and individuals working on the IP have developed shared goals and objectives, and they collaborate to address larger goals.
- Staff attitudes and enthusiasm regarding the work are visibly positive.
- Improved communication, coordination, and implementation are evident, with resulting efficiencies.
- More and better data are available, and it is considerably easier for everyone, including regulators, to access existing data (e.g., groundwater) about the site.

- Exchange of relevant information with the regulators appears to have improved.
- The IP has forced diverse organizations at Hanford to coordinate their programs and to make better multiple uses of data than before.
- There is a focus on productivity and accomplishment, with increases in both.
- There is an applied connection between S&T programs and the practical needs of the IP.
- There is enhanced transparency in decision-making, which is needed to increase acceptance of the results.
- Because "integration" is more of a process than a single objective, there is a commitment to continuous improvement.

There is evidence that the IP has contributed to evaluations and peer review of the remediation strategies that are being deployed. This has contributed to expediting the time frame for decision-making regarding both technical approaches and technologies being used, even on projects underway in the field. However, the IP has yet to demonstrate that it can directly assist in the broader site-wide decision-making that will be required. This is not necessarily a negative because a number of the IP's activities have not yet matured sufficiently to be applicable on a site-wide level. Additionally, it is clear that the site as a whole has not yet articulated the future decisions that must be made.

Focus Session – System Assessment Capability

The focus session on the SAC sought to evaluate the results of attempts by the staff to calibrate the SAC models against historical data - History Matching. The purpose was to accomplish two objectives: (1) to obtain an update on the apparent complications that have emerged in matching the data, and (2) to provide assistance to SAC in order to maintain momentum and achievement of scope and schedule during the change of contractor management. This session was an interim update, and consequently there were no pre-meeting SAC documents available for review.

We commend the SAC Team on clear evidence of progress, concise and well-done presentations in the focus session, and beneficial exchange of ideas in the roundtable sessions.

The contractor transition scheduled for July 1, 2002 is a particularly sensitive time for tasks with long-term goals such as the SAC. We are particularly concerned that the momentum be maintained during this time period. Integration must remain an umbrella goal that transcends changes in staff and contractors.

SAC is an approach that must be endorsed at the level of the site manager to be useful enough to impact major decisions. The IPEP endorses having the future management of SAC within the Site Manager's office rather than at the level of a contractor-led integration.

Focus Session – Vadose Zone Characterization

In the session on the vadose zone characterization being conducted by the Office of River Protection (ORP), evidence was presented that this work is progressing well on several fronts.

The supporting S&T effort is well integrated into the project. The interim actions being taken to protect groundwater, such as controlling run-on at the tank farms and testing and/or decommissioning old water lines, should provide great benefit in a short time frame.

The phased approach to vadose zone characterization being pursued by the ORP seems reasonable. In this approach, based on a yearly cycle, characterization of one tank farm is in the planning stage, while one is in the field-investigation stage, and another is in the data-analysis stage. The approach and execution seem reasonable and important work is being conducted with increasing efficiency.

However, what is largely missing from the discussion currently is the question: *How much characterization is necessary and sufficient?* It would be considered ambitious to expect an immediate answer to this question, because it is linked to key site decisions, such as land use and risk definitions, that have yet to be made. Nonetheless, a plan should be in place that defines the linkages to those key site decisions and shows how objective criteria for deciding how much characterization is needed will eventually be developed.

Another important issue is that while considerable time and effort is spent identifying and quantifying waste volumes in tanks and the extent of contamination in the vadose zone, the IP may not focus enough on what is needed to make Keith Klein's vision for the 200 Area a reality. If indeed the central plateau is going to be a waste disposal area, what do we need to know to make it a safe disposal area for generations to come? Could DOE, without monitoring the vadose zone, be creating another major waste problem for future generations?

Focus Session – Science and Technology Projects

The Science and Technology (S&T) focus session dealt primarily with research projects and laboratory support for field investigations in the S and SX tank farms. Due to time limitations, discussion focused on three projects of fourteen supported by DOE Headquarters through the Environmental Management Science Program (EMSP), as well as several projects funded at approximately $400,000 from the on-site S&T budget.

The approach, accomplishments and findings of the S&T program are extremely important for the development of "correct" or "accurate" conceptual models for the site. The scientific findings are especially noteworthy, in that several provide innovative insights into the mechanisms that determine the rate of migration of certain contaminants.

The objectives that the S&T Program sought to achieve for the S-SX tank farms are: (1) resolve key issues associated with leaks from high-level waste tanks; (2) establish improved conceptual models for processes controlling contaminant distribution and potential for future migration of contaminants; and (3) impact decisions for interim actions and long-term tank-farm closure.

The presentations, the subsequent discussions and the roundtable session focused mostly on issues evolving from the second objective above. The S&T approach to meeting the objectives and resolving the scientific issues was a significant example of integration across programs, disciplines

and organizations. The quantity and quality of research is impressive. The IPEP looks forward to an opportunity to review a forthcoming comprehensive report.

Equally impressive is the highly cooperative atmosphere that appears to exist among S&T and the ORP and Environmental Restoration programs.

While the outcome of the session was very positive, the IPEP is concerned about what will happen to the highly effective S&T effort as EMSP funding dwindles or ceases.

Field Trip (Dr. Wierenga)

At the request of Dr. Wierenga, a field trip was organized on April 24, 2001. The purpose of the field trip was to become more familiar with some of the vadose zone experiments being conducted at the Hanford site. A second reason for the field trip was to assess the extent of vadose zone monitoring below the existing disposal facilities. Stakeholders and regulators also attended the field trip.

The Environmental Restoration Disposal Facility (ERDF) and the submarine-reactor disposal pit were visited to observe vadose zone monitoring at the facilities. It was discovered, however, that neither of these sites currently have any vadose zone monitoring activities. Furthermore, it appears that no equipment or instrumentation for vadose zone monitoring has been installed in any of the other disposal facilities in the 200 areas.

Although ERDF is designed with two plastic liners in accordance with EPA and state guidelines, and appears to be a well operated and managed facility, the absence of any vadose monitoring at this or any other disposal site in the 200 areas is troublesome. We are concerned that the only method now employed to measure contaminant migration is to monitor for contaminants in groundwater. DOE could possibly create a large liability in the 200 Area within the next 50 to100 years.

The vadose zone field experiments visited on this field trip were well conceived and executed. The results from the experiments (also presented and discussed as part of the S&T session) should provide important data for testing conceptual and numerical models of vadose zone flow and transport processes in the upper vadose zone.

RECOMMENDATIONS

General

- As the FY02 budget discussions proceed and the "top-to-bottom" review of EM takes place, the IPEP encourages DOE to recognize that the IP can be of considerable value in helping to prioritize efforts and identify efficiencies. Opportunities for additional integration at Hanford should be identified and pursued.

- In transitioning the IP to Fluor, the plans that are put into place by DOE-RL need to assure that the benefits of "integration" obtained to date are not lost.

System Assessment Capability

- The SAC team should state clearly what likely can and cannot be done with the SAC model, as well as how it differs from other onsite modeling efforts; e.g. limitations, uncertainty.

- The SAC team should strive to define clearly what is being left out and how critical gaps might be filled.

- The SAC team should define and clarify with examples such terms as " History Matching" "Calibration", "Testing" and "Validation". Further, we suggest that the Peer Review Team be assigned the task of providing feedback on "How to evaluate the adequacy of calibration?" and "How to evaluate, or test SAC?" for the site-wide capabilities.

- The SAC team should define the level of documentation of Rev. 0 needed at this juncture for Peer Review and communication of achievements. Where relevant, SAC should communicate rules, assumptions, criteria, principles, and standards.

- The SAC team should pursue opportunities that exist now to integrate performance assessment (PA) activities with ORP in several venues (e.g. ILAW) and this can also be used to build confidence in the modeling efforts of both groups. This comparison to other PA efforts will allow a clear contrast in scale, capability, and also demonstrate ranges of outcomes to the modeling.

- Transfer of the SAC modeling components as a comprehensive conceptual model and mathematical tool, while preserving the envelope of close scientific interaction, must be considered in the transfer of scope to other contractors.

- The ultimate "Home" or "Ownership" of SAC should be the site DOE Integration Office. Even though actual calculations are done at PNNL or by other contractors, the SAC function needs to be given significant exposure and use at the site-management level.

Vadose Zone Characterization

- DOE-RL and ORP should develop a plan for establishing an acceptable level of confidence in the output of the computer models and the predictions based on that output.

- DOE-RL and ORP should pursue opportunities for integrating the modeling efforts of various programs, if that would improve overall efficiency.
- DOE-RL should develop a plan that defines the linkages of site characterization activities to key site decisions and sets out how objective criteria will be developed for deciding how much characterization is necessary and sufficient.

Science and Technology Program

- The S&T program should continue the close relationships with the ORP and ER.
- The S&T program should seek additional EMSP, as well as on-site S&T, funding.
- The S&T program should work closely with the SAC to insure incorporation of the new concepts developed from the S-SX effort, and from any new research.
- The S&T research effort should be extended to other areas on the site.

Field Trip (Dr. Wierenga)

- It is strongly recommended that all new waste disposal facilities in the 200 Area have horizontal plastic or metal pipes installed to provide access for vadose zone monitoring below the facilities. These pipes should serve as conduits for present (neutron moisture measurement) as well as future (geophysical and other methods) vadose zone monitoring.

- Consideration should be given to installing a vadose zone leak detection system below all liquid effluent disposal facilities.

- DOE needs to play a proactive role in vadose zone monitoring below all present and future waste disposal facilities to prevent groundwater contamination problems from occurring in the future.

1. INTRODUCTION

1.1 Context of Meeting

The ninth meeting of the Integration Project Expert Panel (IPEP) took place within the context of considerable uncertainty, largely due to the drastically reduced budget proposed for DOE-EM for FY02 and the forthcoming transfer of Integration Project (IP) responsibility to Fluor in July 2002. Together, these two major issues raise concerns about the ability of the IP to maintain momentum on their tasks and vision and, more fundamentally, the future of "integration" at Hanford. This set of circumstances serves as a reminder that continuing progress and success at Hanford is dependent in part on the nation's political agenda and changing priorities.

1.2 Agenda and Format of the Meeting

The format for this meeting (see Agenda at Appendix B) differed somewhat from that of previous meetings. Each day, following formal presentations and discussions, a roundtable session was scheduled for unstructured discussion about the key issues needing further comment. These sessions were attended and contributed to by the public, as well as by the IPEP and the presenters. Stakeholders, Tribal Nation representatives and regulators were afforded an opportunity to comment prior to the roundtable sessions, rather than having to hold their comments to the end of each day. This facilitated an open discussion, not only of the presented material, but also of the remarks by the interested parties. This format appears to have been successful and will be considered for the upcoming September 26-28, 2001 IPEP meeting.

2. HANFORD VISION UPDATE

Announcement of the reduced FY02 budget for DOE's Office of Environmental Management (EM) several weeks before the IPEP meeting cast doubt on the ability of the DOE-Richland Office (DOE-RL) to continue advancing the Hanford 2012 Plan that has been under development to accelerate cleanup activities on site. At the time of the meeting, the projected FY02 budget for DOE-RL was reduced by $300-million from what it is in the FY01 budget. At that level, it is likely to require major modifications in current thinking and perhaps eliminate or greatly reduce important ongoing projects, especially those activities that were planned for the river corridor.

Hanford site Manager, Keith Klein, confirmed that since there were no provisions for extending the current BHI contract for the IP, the contract would come to a close as planned at the end of June 2002. However, he stressed that it was his intention to continue the IP under the auspices of Fluor Hanford. He further indicated that DOE-RL would assume more active involvement and ownership of the IP. A transition effort involving Fluor Hanford could be expected to be in place several months before the BHI contract comes to an official close.

Secretary of Energy Abraham has requested that EM carry out a "top-to-bottom" review in an effort to identify further efficiencies and more effective ways to continue its efforts. Details regarding how this review would actually take place were not available at the time of the meeting.

Mr. Klein indicated that he wanted the IPEP's views regarding the IP's progress during the past six months, especially the relevance of the IP with respect to decision-making on site. More specifically, he wanted to know how the IP could affect the decisions that need to be made. He believes the Systems Assessment Capability (SAC) can be relevant to defining the "end game" for the Site, but he wanted the IPEP's views. He continued to indicate his support for a coordinated and integrated approach to Hanford site cleanup. Further, he stated there would be efforts to utilize products and information from the IP to establish the overall remediation strategy for the Central Plateau, including action levels, points of compliance, and future land use.

2.1 Observations

The IPEP commends the IP and the related core projects for their accomplishments. The IP has accelerated its rate of progress in several key areas, including:

- Definition of inventory;
- Easier, more centralized access to data about the Site;
- Data on subsurface characterization in and around tank farms;
- Integration of science and technology efforts directly into the IP to yield relevant results; and
- SAC history matching.

In addition, the IP has strengthened its linkages both internally and externally at Hanford. Internally, the organizations involved in the IP have been linked through co-location, while externally the IP has contributed to wider acceptance of the integration concept through changes in the governing

culture. The overall result is better coordination and more effective use of resources. These linkages and culture changes need to be further encouraged and preserved.

However, while it is clear that the IP has made great progress, many key efforts are not yet complete. These key efforts include agreement on end-states for the various contaminated areas providing sources of contamination to the subsurface, agreement on the definition of target protection levels in the Columbia River, and incorporation of cultural values of stakeholders into the decision making process for Hanford site cleanup.

2.1.1 Benefits of Integration

One of the roundtable discussions addressed the question "What, after several years of effort, have we perceived as the added benefits of integration." A summary of the benefits that were identified by the IPEP is provided below:

- Organizations and individuals working on the IP have developed shared goals and objectives, and they collaborate to address larger goals.
- Staff and organizational attitudes and enthusiasm regarding the work are visibly positive.
- Improved communication, coordination, and implementation are evident, with resulting efficiencies.
- More and better data are available and it is considerably easier for everyone, including regulators, to obtain existing data (e.g., groundwater) about the site.
- The IP has lead diverse organizations at Hanford to coordinate their programs and to make better as well as multiple uses of data.
- Exchange of relevant information with the regulators appears to have improved.
- There is a focus on productivity and accomplishment, with increases in both.
- There is an applied connection between S&T program and the practical needs of the IP.
- There is enhanced transparency in decision-making, which is needed to increase acceptance of the results.
- Because "integration" is more of a process than a single objective, there is a commitment to continuous improvement.

2.1.2 Decision-Making at Hanford

A major purpose of the IP's work is ultimately to contribute to decision-making regarding site-wide cleanup at Hanford. Decisions that shall have to be made will occur in a variety of forms. Some decisions will have only a limited scope, such as the deployment of some technology at a particular place, or implementation of a localized remedial strategy. Other decisions will have a broader scope associated with site-wide issues that often have important components that are neither technical nor scientific in nature.

Over the past three years, the IP has contributed to improving the remediation strategies and technologies that are being deployed in the field. However, the IP has yet to demonstrate that it can directly assist in the broader site-wide decision-making that will be required. This is not necessarily a negative because a number of the IP's activities have not yet matured sufficiently to be applicable on a site-wide level. Additionally, it is clear that the site management as a whole has not yet articulated all of the future decisions that must be made.

2.1.3 Integration Project Transition

The IPEP is pleased that DOE-RL intends to continue the IP after June 2002. According to DOE-RL, the IP will then be under the direction of Fluor Hanford and will retain most of the current scope of activities. However, the IPEP understands that increased coordination by DOE-RL is planned.

The IPEP underscores that the transition of the IP poses some unique challenges, particularly because "integration" is not yet a site-wide reality.

2.2 Conclusions

Based on the information conveyed during the meeting and the roundtable discussions that took place, the IPEP concluded that:

- The IP has made progress on many technical fronts in the past several years at Hanford.
- The concept and implementation of "integration" by the IP and by other units at Hanford has been a very valuable stimulus to this progress.
- The continued commitment and perseverance of IP management and staff are yielding visible benefits.
- DOE-RL is now demonstrating increased ownership of the concept of "integration" and its benefits.

2.3 Recommendations

- As the FY02 budget discussions proceed and the EM "top-to-bottom" review takes place, the IPEP encourages DOE to recognize that the IP can be of considerable value in helping to prioritize efforts and identify efficiencies. Opportunities for additional integration at Hanford should be identified and pursued.

- In transitioning the IP to Fluor Hanford, the plans put into place by DOE-RL need to assure that momentum and the benefits of "integration" to date are not lost.

3. SYSTEM ASSESSMENT CAPABILITY UPDATE

The focus session on the efforts of the SAC Team to "calibrate" model components by matching output against historic data – "History Matching" - was included in this meeting to accomplish two objectives: 1) to obtain an update on the apparent complications that have emerged in matching the data, and 2) for the IPEP to provide assistance to SAC in order to maintain momentum and achievement of scope and schedule during the change of contractor management.

This session was an interim update and there were no pre-meeting SAC documents available for review and no summary or project documents were due at this time. All the information we acquired came solely from the presentations and discussions at the meeting. The focus session consisted of six formal presentations over a two-hour time period, with half of the time allocated to questions and discussion (see Appendix B).

3.1 Observations

The IPEP commends the SAC Team on clear evidence of progress, concise and well-done presentations in the Focus Session, and beneficial exchange of ideas in the roundtable sessions. The groundwork for the session was done prior to the meeting in conference calls and was useful in focusing the session on key issues.

3.1.1 Transition

The contractor transition scheduled for July 1, 2002 is a particularly sensitive time for tasks with long-term goals such as the SAC. We are particularly concerned that the momentum be maintained during this time period. SAC has had recent success in the construction and initial calibration through history matching for each of the SAC modeling components. The testing and validation phase will be initiated during this coming year during the transition, a time period in which personnel and budgets are changing. Some additional effort may be required to successfully complete this phase. As such, the September 2001 IPEP meeting will be timely for a detailed SAC focus session.

SAC is an inter-disciplinary effort requiring input and coordination from many disciplines, not just the programmers. This is noteworthy in times of budget austerity and transition. The success of the SAC model as a device for assisting in performance assessments depends on its comprehensiveness. Thus, for example, the SAC team must incorporate biological endpoints and measurements of ecological health into its modeling efforts. This, in turn, depends on a closely coordinated, cooperative effort among a team of scientists in physical, chemical and biological disciplines and across several contractors to assure the meaningful framing and use of the SAC analysis.

Occasional scientific input to a modeling function will not be sufficient for success. For success, especially in a time in which management and personnel are changing, the SAC effort must maintain linkages to other projects and the critical mass of scientific and technical professionals. Another way to make this point is to say that the scope of the SAC includes more

than the personnel needed to execute the programs and this rather intangible aspect can be easily lost during restructuring. Therefore, the IPEP encourages contractors involved in SAC to preserve this envelope of close interaction through and beyond the transfer of scope.

SAC is an approach to assist decision-making that must be endorsed at the level of the Site Manager to be useful enough to impact major decisions. It may be that management of SAC should be within the Site Manager's office rather than at the level of a contractor-led integration project. The Site Manager's office, rather than just the SAC project, should be listing key questions that it wants SAC to consider and should manage the accomplishment of answers to those questions.

3.1.2 Model Defensibility

The usefulness and defensibility of the SAC modeling effort and results will certainly be challenged at many stages. It is clear, even at this early stage of development, that there already exists significant confusion about the way in which the model will be used, the expectations of what the model will provide as a result, and how the model will be confirmed as "correct." In the second presentation, led by Charlie Kincaid, a clear example of the method of History Matching was given. This effort is not intended to be model "validation," but rather one step in the calibration of the individual modules, using selected data from each of the regimes defined as either source or pathways, e.g. inventory, vadose zone, ground water or river.

The defensibility of the modeling will require precise definition of terms such as "History Matching," "Calibration," "Testing," and "Validation," which are commonly misused and unevenly applied across disciplines. No model is ever considered perfectly true or correct, so what is the expectation for SAC and how will confidence in the model be built? How do we know it is sufficiently accurate? These are issues of both communication and use.

The Public and the users on the one hand need to know what the terms like "tested" and "validated" mean to the project, and on the other hand the users also need to have an objective mathematical definition of the calculated risk. These are separate issues. The Peer Review group scheduled to meet during the summer of 2001 could also address the definition of these terms and the most effective way of communicating their use.

SAC would benefit from a discussion of specific expectations for the use of the model that includes the scale, time frames and level of uncertainty that will be needed for key decisions. For example, it appears that some Performance Assessment (PA) work being done now by the Office of River Protection is sufficient at the level of one-dimensional transport with stream tubes from the tank farms to the river.

Such a simplification of a complex modeling problem is assumed to provide an upper-bound estimate of potential impacts. However, over-estimation of potential impacts to the public is merely a transferal of low and unlikely risks from the population at large to greater and more likely risks to workers who must remediate the condition. Is this level of uncertainly sufficient for SAC?

3.2 Concerns

Documentation of progress made by the SAC team on Rev. 0 is needed; however, extensive documentation requires diversion of resources and delay in testing. A comprehensive summary document is due as a deliverable in the fall of 2001. We are concerned that the level of effort currently scheduled for preparation of this documentation could interfere with the testing, demonstration of capabilities, and proof of concept, during the 2001 and early 2002 time frame. Some level of documentation is clearly needed and the question that must be addressed soon is how to balance these activities. The SAC team will participate in a peer review of the History Matching exercise in the summer of 2001. Some documentation will be required for this activity, and this effort should not be wasted, but be utilized as part of the documentation effort needed in the fall of 2001.

3.3 Recommendations

- The SAC team should state clearly what likely can and cannot be done with the SAC model, as well as how it differs from other onsite modeling efforts; e.g. limitations, uncertainty.

- The SAC team should define and clarify with examples such terms as " History Matching" "Calibration" and "Testing" and "Validation". Further, we suggest that the Peer Review Team be assigned the task of providing feedback on "How to evaluate the adequacy of calibration?" and "How to evaluate, or test SAC?" for the site-wide capabilities.

- The SAC team should define the level of documentation of Rev. 0 needed at this juncture for Peer Review and communication of achievements. Where relevant, SAC should communicate rules, assumptions, criteria, principles, and standards.

- The SAC team should pursue opportunities that exist now to integrate performance assessment (PA) activities with ORP in several venues (e.g. ILAW), and this can also be used to build confidence in the modeling efforts of both groups. This comparison to other PA efforts will allow a clear contrast in scale, capability, and also demonstrate ranges of outcomes to the modeling.

- Transfer of the SAC model components as a comprehensive conceptual model and mathematical tool, while preserving the envelope of close scientific interaction, must be considered in the transfer of scope to other contractors.

- The "Home" or "Ownership" of SAC should be the site DOE Integration Office. Even though actual calculations are done at PNNL or by other contractors, the SAC function needs to be given significant exposure and use at the site-management level.

4. VADOSE ZONE CHARACTERIZATION PROJECT

4.1 Overview

In the session on the vadose zone characterization being conducted by the River Protection Project (RPP), Anthony Knepp presented evidence that this work is progressing well on several fronts. The supporting Science and Technology (S&T) effort is well integrated into the project. The interim actions being taken to protect groundwater, such as controlling run-on at the tank farms and testing and/or decommissioning old water lines, should provide great benefit in a short time frame.

4.2 Observations

4.2.1 Characterization

The IPEP commented in the closeout report for the October 2000 meeting that the phased approach to vadose zone characterization being pursued by the RPP seems reasonable (IPEP, 2000a). In this approach, based on a yearly cycle, one tank farm is in the planning stage, while one is in the field-investigation stage, and another is in the data-analysis stage. During the April 2001 IPEP meeting, we received a broader update regarding the ongoing characterization work and, again, the approach and execution seem reasonable – important work is being conducted with increasing efficiency.

However, what is largely missing from the discussion currently is the question: *How much characterization is necessary and sufficient?* Some might argue that a substantial increase in the rate of characterization is needed, while others might feel that no further characterization is needed. It is perhaps unrealistic to expect an immediate answer to this question because it is linked to key site decisions, such as land use and risk definitions, and to what is needed for SAC. Nonetheless, a plan should be in place that defines the linkages to those key site decisions and shows how objective criteria for deciding how much characterization is needed will eventually be developed. Over time, this will allow the characterization effort to be focused more precisely on the information that is most needed and allow the characterization to be terminated at the optimal time.

In the closeout report from the January 2000 IPEP meeting (IPEP, 2000b), we expressed concern that vadose zone characterization was being conducted at a much slower pace than originally planned. In his presentation at the April 2001 IPEP meeting, Mr. Knepp emphasized that the characterization effort has changed substantially over the past year, including new operational efficiencies and many recent technical advances, yielding “dramatically more information for the same money.”

The earlier Vadose Zone Expert Panel (VZEP), and more recently the IPEP, commented critically on the apparent entrenched institutional resistance to innovation in characterization at Hanford, including an almost exclusive reliance on cable drilling for borehole investigations. The VZEP and IPEP recommended the implementation of techniques such as air rotary drilling, slant drilling, and sidewall sampling. These

techniques and others have since been developed and used effectively. The Panels also recommended that the possibility of re-entering the laterals under some of the tanks at waste management area (WMA) S-SX for new measurements be investigated, and that is now being done. These are great steps forward in the characterization effort, and it is the IPEP's view that the vadose zone characterization project is making good progress considering the budget available for this effort.

4.2.2 Leak Inventory

Mr. Knepp identified the tank farm leak inventory as being essential as a source term for various models. However, the source term has been found to be difficult to evaluate. Rather than model the leaks themselves, the ORP program has taken leak inventory estimates as an initial condition. Mr. Knepp reported that the leak quantities were estimated by recovering all the historical information, including operational data and gamma-ray logging data, and by systematically re-evaluating which data support the existence and estimated leak quantities of the various known and assumed tank leaks, a process Mr. Knepp referred to as professional judgment. Recalling that the Columbia River Comprehensive Impact Assessment (CRCIA) calls for minimizing use of professional judgment in such decisions, it will be important to establish that its use is reasonable in this case.

The estimated leak quantities at the S-SX tank farms, as presented by Mr. Knepp, ranged from 86.9 KCi (MSU kriging calculations) to 1,010 KCi (from early work by Agnew). The series of Hanlon reports provide estimates ranging from 127 KCi to 251 KCi. Currently an estimate of 117 KCi (based on "updated data.") is being used in the modeling. This estimate is near the low end of the range of estimated leak inventories and, as such, the burden is on the ORP to demonstrate that this assumed value is reasonable in light of the many inherent uncertainties in any such estimate. When considered in concert with ORP's previously described "stream-tube" approach to vadose zone transport of contaminants (section 3.1.2, preceding), it becomes apparent that this "mix-and-match" approach (over-estimates combined with under-estimates) can lead to highly uncertain results and can undermine the confidence of the public. Mr. Knepp commented that inventory estimates are "driven" by the data from the laterals under some of the tanks, and plans are under way to re-enter some of the laterals for updated measurements, a concept the IPEP continues to support.

4.2.3 Modeling

Finally, Mr. Knepp presented results from two-dimensional modeling on three cross sections across S-SX tank farms. Included were calculated breakthrough curves for ^{99}Tc at the water table and at the WMA boundary. These breakthrough curves were converted to dose estimates, and 1000-year contamination curves were generated at various locations.

The issue of confidence in predictions based on computer modeling at Hanford is of paramount importance, and continues to be of great concern to the IPEP. While all

computer-modeling programs are capable of generating reams of results with a great degree of precision, the question remains whether the accuracy of a given model can be trusted for a given application. Confidence must largely be based on appropriate calibration and testing of the models and necessarily will develop slowly over time.

The concepts of calibration and validation of computer models are presently hotly debated in the scientific literature. The IPEP is particularly concerned about developing confidence that the modeling predictions are reliable for the various applications for which the models will be used. In discussions during this session of the meeting (as well as in the SAC History Matching session discussed elsewhere in this report), it emerged that there is currently no consensus for how predictive confidence can be achieved.

Nonetheless, for each model or set of models that is expected to yield important predictive results, it is essential that a plan for establishing confidence in the results be developed. In the case of the type of modeling presented in this session (as well as the models used in the SAC), establishing confidence will probably be difficult and creative thinking will be required.

As the IPEP considered the modeling being conducted by the ORP, by the SAC, and in other more or less independent projects, the question once again arose: *Does DOE have an optimum integration plan for modeling?* Some of these modeling efforts were conceived in pre-integration days, and it may make sense to continue their use as independent efforts for a while. In the interest of cost efficiency, however, the various modeling activities across the site, especially the longer-lived modeling activities, should be considered as candidates for further integration over time.

Mr. Knepp identified the Plio-Pleistocene lithologic unit underlying S-SX tank farms as the "controlling rate unit" for contaminant transport from the vadose zone to groundwater. Because the detailed properties of the Plio-Pleistocene are not correlatable across the tank farm, he raised the question of whether it is worth the effort of improving knowledge about the properties of this lithologic unit. He offered the opinion that improved property estimates would likely make a difference for closure decisions, but not for interim measures.

Others at Hanford believe that what really determines the rate of contaminant transport to the groundwater at this site is the rate of downward moving water below the tank farms, or the local rates of recharge. Gee and others estimated recharge at no more than 100 mm per year, which is less than 1/3 mm per day on average. Almost all soils or sediments can accommodate such low flux rates.

Thus, the hydraulic properties are not that important, but the flux rates are. The flux rates are mostly controlled by rainfall, leaking pipes, convergence and runoff from the tank surfaces, root water uptake etc.

Many questions such as this will arise over time, emphasizing the importance of developing a plan for answering the question raised above: *How much characterization is necessary and sufficient*.

4.3 Recommendations

- DOE-RL and ORP should develop a plan for establishing an acceptable level of confidence in the output of the computer models and the predictions based on that output.

- DOE-RL and ORP should pursue opportunities for integrating the modeling efforts of various programs, if that would improve overall efficiency.

- DOE-RL should develop a plan that defines the linkages of site characterization activities to key site decisions and sets out how objective criteria will be developed for deciding how much characterization is necessary and sufficient.

5. SCIENCE AND TECHNOLOGY PROJECTS FOR S-SX TANK FARMS

5.1 Definition of S&T Program

The Science and Technology (S&T) focus session, presented by John Zachara with support from Mark Freshley and S&T staff, dealt primarily with research projects and laboratory support for field investigations in the waste management area (WMA) encompassing the S and SX tank farms. Dr. Zachara focused on three projects supported by DOE Headquarters through the Environmental Management Science Program (EMSP), as well as several projects funded to approximately $400,000 from the IP and EM on-site S&T budget. Other areas of research were not discussed, because of time limitations. A tabulation of other EMSP-funded projects related to the Hanford site is provided at the end of this report (see Appendix B).

The approach, accomplishments and findings of the S&T program, as presented at the IPEP meeting, are extremely important for solution of many of the issues raised previously in this report and in earlier IPEP reports. This is especially true for the development of more representative conceptual models for the site. The scientific findings are especially noteworthy, in that several provide innovative insights into the mechanisms that determine migration of certain contaminants.

5.1.1 S&T Objectives for the WMA S-SX Investigations

The objectives that the S&T Program sought to achieve for the S-SX tank farms are: (1) resolve key issues associated with leaks from high-level waste tanks; (2) establish improved conceptual models for processes controlling contaminant transport and potential for future migration of contaminants; and (3) impact decisions for interim actions and long-term tank-farm closure.

5.1.2 Scientific Issues at WMA S-SX

The presentations, associated discussion periods following the presentations, and the subsequent roundtable sessions focused mostly on issues evolving from the second objective listed above. The factors, properties and processes controlling contaminant transport that were evaluated include: waste sources, composition and releases; thermal history and effects; geohydrologic processes and geologic influences; geochemical reactions; and coupling of processes. The factors that might influence the potential for future migration include: (1) thermal effects on water flux and sorption (however, these effects will decrease in importance over time); (2) stability of ^{137}Cs sorption complex; and (3) mobility of ^{99}Tc, Cr and similar constituents.

5.1.3 S&T Approach and Accomplishments

The S&T approach to meeting the objectives and resolving the scientific issues is a noteworthy example of integration across programs, disciplines and organizations. Various

S&T staff attended programmatic DQO sessions, developed research plans in cooperation with the ORP, sought additional expertise from other national laboratories and from universities; solicited investigators to respond to the request for proposals by the EMSP; distributed sample to the various research centers; performed a focused research program that featured experiments in laboratories, numerical experiments and simulations, and field experiments and tests. Early results were provided to ORP in digest form. Publications and a comprehensive report will follow.

The success of this integrated approach to research is reflected in the quality and significance of the resulting accomplishments, including: close engagement of Hanford with EMSP; development of conceptual models for lateral transport and Cr migration; new insights into the effects of thermal phenomena and source terms; improved numeric models, particularly for multicomponent Cs exchange; and data and modeling for corrective action assessment of drainage effects on recharge and thermal effects on Tc release.

5.1.4 Key Findings

Despite the brief time allotment, Dr. Zachara provided a great deal of data, graphs, and displays of laboratory- and field-test data, as well as displays of the outcomes of numeric modeling simulations of the accumulated laboratory and field information. In addition to the funding provided by EMSP for the Cs research project described below, an additional $10-million in research funds was made available through EMSP for "basic", but targeted, research. A solicitation for proposals was extended to governmental and university research centers by EMSP and funding provided for some fourteen research projects targeted at Hanford requirements (see Appendix C). Three of these research efforts formed the basis of Dr. Zachara's presentation. The following summarizes some of the key findings.

Cs Research. A long-standing and highly contentious question is how ^{137}Cs, leaked from the high-level waste tanks and anticipated to be very immobile, reached depths of 140 feet in the soil column below the S and SX tank farms. [DOE, 1997].

The results showed that Cs K_d values, both in laboratory and field experiments, are highly variable, but the variations in K_d can be represented by models developed from laboratory studies. Sodium, potassium and calcium concentrations in the leaked briny waste liquor and in the soil column, as well as the cation exchange capacity of the soil column, are the principle determinants of $^{137}Cs^-$ migration. Sorbed Cs is exchangeable and the exchange rate can be predicted using the conceptual and numerical models under development at Pacific Northwest National Laboratory (PNNL). The mineral association of $^{137}Cs^-$ is little altered by waste-sediment interaction. The pH of the brine leaked from the tanks in association with the $^{137}Cs^-$ leaks appears to have only a small effect on the mobilization of $^{137}Cs^-$ in the vadose zone. Thus, field profiles developed from core samples can be described with the laboratory data. Future mobilization and transport of $^{137}Cs^-$ is possible, but not expected and transport of $^{137}Cs^-$ into the groundwater is very unlikely at this site.

If the conceptual and numerical models developed from these experiments related to the S-SX tank farms are supported by field investigations, they appear to provide an

explanation of how $^{137}Cs^{-}$ was transported to the depths observed in some tank farms. The S&T research effort may finally lay the issue to rest.

Cr Research. Cr(VI), as dichromate ion ($Cr_2O_7^{2-}$), was used extensively throughout the site as an oxidizing agent, particularly to adjust the valence states of uranium and plutonium. Dichromate ion is highly mobile as a contaminant in the environment, whereas the reduced form, Cr(III), is relatively immobile compared to Cr(VI). The mobility and toxicity of Cr(VI) make it an important contaminant, so redox control in the environment is a key factor for reducing risk. Approximately 30% to 60% of the Cr(VI) present in the REDOX tank-waste is reduced by natural reactions and immobilized in sediments as precipitated Cr(III). In situ mapping showed Cr(III) is associated with biotite and ilmenite. Laboratory studies indicated that the reduction reaction is facilitated by hydroxide ion (OH^{-}). The extent of reaction is limited by kinetic controls. A conceptual model has been developed to explain Cr(VI) reaction with soil.

Also, Cr(VI) has been expected to serve as a surrogate for predicting and/or following the transport of other relatively mobile contaminants, such as $^{99}TcO_4^{-}$ ion. The research found that Cr(VI) as dichromate ion is somewhat less mobile than is ^{99}Tc(VII) as pertechnetate ion. The 30% to 60% fraction of the Cr(VI) that is immobilized as precipitated Cr(III) allows the Tc(VII) front to move out ahead of the Cr(VI) front. While still somewhat useful as an indicator, Cr(VI) does not appear to serve well as a measure of arrival time for pertechnetate ion.

Thermal Effects in the S-SX Tank Farms. Liquid REDOX wastes were initially boiling from radiolytic heating and reached peak temperatures of 140C to 200C. Large amounts of hot liquids containing ^{137}Cs and other contaminants were released to ground. The tanks and surrounding soil are still quite hot. The high temperatures influenced the moisture regime and solute distribution in the vadose zone beneath the tank farms during the early releases and the continuing heating of the soil exerts an influence on moisture and solute distribution even now. In the future, heat loading will affect recharge and drainage, contaminant break-through, and leak losses. On this basis, thermal modeling will be an important part of impact assessments.

"Heat pipe" evaporation condensation and liquid recirculation cause dynamic drying and wetting cycles with corresponding concentration, precipitation and mobilization of salts around the tank heat source. Temperature, moisture content, and chemistry provide important constraints on volume estimates of tank leaks. Non-isothermal modeling is necessary for retrospective projections of contaminant injection and migration, but assumption of isothermal conditions appears to be valid for future projections.

Field Injection Experiments. With water as a carrier for all contaminants, solute distribution patterns suggest heterogeneous migration. There has been evidence for, but no direct observation of, lithologic effects on water migration. Field injection experiments were conducted to develop comprehensive data sets for model testing, evaluation and improvement and to resolve issues on migration of saline, dense fluids through the ground. Five injections of 4000-L each were made over five weeks, the third injection including a bromide (Br^{-})

tracer. Geophysical logging was conducted using a suite of methods. (See also observations at 6.1 of this report.)

The field injection experiments have provided information from which the S&T team was able to develop new and to enhance old conceptual models. Temperature, moisture content, and chemistry provide important constraints on volume estimates of tank leaks. The bromide tracer was redistributed along textural interfaces, in a manner similar to redistributions observed in the tank farm that have been attributed to new leaks. Additional development of geophysical methods is needed to provide vertical resolution adequate for model calibration. The effects of heat generated by tank waste and contaminants in the soil is necessary to make representative projections of contaminants leaked previously from tanks into the soil and their subsequent migration, but assumption of isothermal conditions appears to be valid for projections of future leaks and their migration

5.1.5 S&T Contributions to WMA S-SX Investigations

The S&T organization has worked closely with the ORP vadose zone characterization effort to provide interpretation of characterization results for: source terms (composition, speciation, timing); water buildup/migration patterns; chromatographic mechanisms for solutes; additional analytes; and advanced speciation analysis. The S&T program has affirmed modeling assumptions with regard to isothermal assumption for Tc release, drainage analysis, and the importance and contribution of other processes. The outcome is an improved basis for leak-loss assessment and long-term projections of water mobility in the soil column (heat effects, storage, and redistribution), solute mobilization and transport (Cs, Cr, Tc) and evaluation of hitherto unknown issues.

The results of this close liaison between the two organizations have been reported at several previous IPEP meetings and again here. The successes achieved in evaluating cores from near tanks SX-109 and SX-115, as well as the revolutionary (for Hanford) slant-hole beneath tank SX-108, received commendation in previous IPEP reports. The empirical temperature profiles reported earlier by the Vadose Zone Expert Panel [DOE, 1997] have now been enveloped into a conceptual model that appears to explain many of the results obtained from core samples of ^{137}Cs and ^{99}Tc migration beneath and in the proximity of the tanks. An apparent side benefit of the analysis of thermal effects is a better understanding of the mechanisms that determined the leak rates of these radionuclides from various tanks.

5.1.6 Future Directions

The general goal of the S&T program is to enhance quality and credibility of performance assessments and risk analyses so as to enable economically prudent decisions that protect the environment and health. The goal is to be achieved by providing focused science and coordination in support of RPP's WMA S-SX assessment. The S&T effort will be extended to other tank farms, more immediately to tanks BX-102, B-112 (U and Sr-EDTA) and T-106 (organic complexation effects), and to 200 Area soil sites that also pose unique problems, such as with Pu/Am, anomalously-distributed U and carbon tetrachloride in 200 west. FY 2001 activities also include field experiments with injection of dense fluids,

improvement in geophysical methods; e.g., through-casing electrical resistance tomography (ERT), and completion of data analysis.

5.2 Observations

Time restrictions limited the S&T presentation to only 3 of 14 EMSP-funded studies, as well as to the work funded through the Hanford research budget. Despite the limitation, the quantity and quality of research is impressive. The IPEP looks forward to an opportunity to review the forthcoming comprehensive report on the entire S&T program.

Equally impressive is the highly cooperative atmosphere that appears to exist between S&T and the ORP and Environmental Restoration programs. In stark contrast to the "stove piping" that was observed prior to the IP, the S&T program, with the cooperation of the other two organizations, now provides fundamental, yet focused, information necessary to resolve issues affecting the tasks of the core organizations.

The positive interaction during the second roundtable session among members of the three organizations and SAC members provided for a lively and informative discussion. This was a welcome sign to the IPEP of the degree to which integration has improved at the site.

5.3 Issues/Concerns

While the outcome of the session was very positive, the IPEP is concerned about what will happen to the highly effective S&T effort as EMSP funding dwindles or ceases. Also, there must be a concerted effort to provide/obtain research funds for S&T research on other parts of the site at the level of effort to which the S-SX research program was funded.

While the spirit of cooperation was evident among the staff attending the meeting, there remains concern on the part of the IPEP about the degree to which the S&T concepts will be incorporated into the work of the core organizations or into SAC.

5.4 Conclusions

- The S&T effort with regard to the S-SX tank farms is highly successful.
- The concepts developed by and still developing from the S&T program are important to the success of SAC and the core projects.

5.5 Recommendations

- The S&T program should continue the close relationships with the ORP and ER.
- The S&T program should seek additional EMSP, as well as on-site S&T, funding.
- The S&T program should work closely with the SAC to insure incorporation of the new concepts developed from the S-SX effort, and from any new research.
- The S&T research effort should be extended to other areas on the site.

6. REFERENCES

DOE, 1997. TWRS Vadose Zone Contamination Issue Expert Panel Status Report, DOE/RL-97-49 (Revision 0), April 1997. U. S. Department of Energy, Richland, WA.

GAO 1992. Nuclear Waste, Improvements Needed in Monitoring Contaminants in Hanford Soils. Report to the Chairman, Committee on Governmental Affairs, U.S. Senate. GAO/RCED-92-149: 1-17. General Accounting Office, Washington, DC.

IPEP, 2000a. Integration Project Expert Panel: Closeout Report for the Meeting Held October 25-27, 2000. U.S. Department of Energy, Richland, WA.

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Appendices

Appendix A

FIELD TRIP

Dr. Peter Wierenga

At the request of Dr. Wierenga, a field trip was organized for him on April 24, 2001. The purpose of the field trip was to become more familiar with some of the vadose zone experiments conducted at the Hanford site and to convey to the entire Panel the field observations. A second reason for the field trip was to assess the extent of vadose zone monitoring below the existing disposal facilities. Mark Freshley and Dr. Glendon Gee, both from PNNL, organized the field trip. Several representatives of the State of Washington Department of Ecology participated in the field trip.

A.1 Observations

Two facilities, the field-test lysimeter facility and the Hanford surface barrier facility, continue to generate important field data on percolation rates in deep soil profiles under natural and enhanced rainfall rates. The data from these facilities have shown that it is quite possible to construct soil profiles and establish vegetation on these profiles that essentially reduce deep percolation rates to zero.

Two other facilities, the Mock Tank Site and the Buried Waste Test Facility (VZTS-300) are used to test current monitoring techniques. At the Mock Tank Site, geophysical techniques are used to detect leaks below a tank. Water is applied to the soil surface within an enclosed area (a Mock Tank), and the presence of this water leak is detected with geophysical instruments in boreholes around the Mock Tank. At the Buried Waste Test Facility advanced tensiometers, used to measure the soil water pressure in unsaturated soils, are being tested. So far results from the tensiometer tests look very promising. The tests at the Mock Tank Site will be conducted this summer.

The above-described tests are useful. The deep tensiometers can be used, if tests continue to be successful, to help establish deep percolation rates around the tanks in the various tank farms. These percolation rates are presently not well known. The tests of the geophysical techniques should help clarify whether geophysical techniques yield reliable results in detecting tank leaks in the vadose zone.

The Vadose Zone Transport Field Study also was visited. In this study traditional soil physics techniques and newer geophysical methods are used to track plumes of water injected underground. The experiments are well conceived and executed. Results should be helpful in deciding whether geophysical techniques are useful for vadose zone monitoring in Hanford.

The Environmental Restoration Disposal Facility (ERDF) also was visited and a short stop was made at the submarine reactor disposal pit. Our interest was to observe vadose zone monitoring below the facilities. At both of these sites there is no vadose zone monitoring, and apparently no vadose zone monitoring was installed in any of the other

disposal facilities in the 200 areas, such as the Liquid Effluent Retention Facility (LERF). Moist soil removed from contaminated sites is disposed at the ERDF. In order to compact the soil and for dust control, a fairly large volume of water is used during disposal. The site is underlain by two plastic liners, which are sloped, so drainage water moves to collection points from where it is pumped to an aboveground storage tank. A large volume of effluent is collected from the upper liner, but only a small volume of effluent is collected from the lower liner.

Although the ERDF is designed in accordance with EPA and state guidelines, and appears to be a well operated and managed facility, the absence of any vadose monitoring at this site and at other disposal sites in the 200 area (especially at LERF) is troublesome. If something were to go wrong (likely, since the liners have a design life of only 30 years and the surface covers to be installed after the facility is full may not perform as expected), there is no way to determine if and when effluent is on its way to the groundwater, until it reaches the groundwater. In a report to Congress in 1992 the General Accounting Office (GAO, 1992) reported that since so much of Hanford's waste is disposed in the ground "it is important to monitor and characterize the extent of contamination in the vadose zone and determine whether it is migrating to the groundwater".

The GAO report focused mostly on tank farms and active liquid waste disposal cribs where monitoring programs were found ineffective. However, the same can be said today about all active waste disposal facilities. Because there is essentially no vadose zone monitoring below the disposal facilities (tank farms excluded), DOE could possibly create a large liability in the 200 areas within the next 50-100 years. At present there is no way of knowing the extent of this future liability.

It is clear that in waste disposal large errors were made at Hanford over the past 50 years, even while following established rules, regulations and engineering practices. DOE should make sure that such errors are not made today. DOE should do better than just to follow the rules and regulations that apply to other types of waste disposal facilities. These rules and regulations are largely based on experience in areas of the country with relatively shallow groundwater table, where waste effluent is detected in the groundwater in a relatively short time and monitoring of the groundwater quality makes sense. The situation in Hanford, where water tables are deep and rainfall rates are low, requires a different approach. Here vadose zone monitoring close to the source of contaminants is required. Although it is clear that some vadose zone monitoring techniques, such as a variety of geophysical techniques, are still under development and need more testing, other methods such as the neutron moisture meter for water content measurements are readily available. Thus DOE should consider installing horizontal access pipes, both plastic and steel, below any newly constructed disposal site. This would provide easy and relatively inexpensive access to the vadose zone below the disposal site for leak detection. Such access pipes could be used right now for monitoring for leaks by pulling a neutron moisture meter through the pipes. If additional geophysical devices became available in the future, they could likewise be pulled through the access pipes and used for leak detection.

A.2 Conclusions:

The vadose zone field experiments visited on this field trip were well conceived and executed. The results from the experiments should provide important data for testing conceptual and numerical models of vadose zone flow and transport processes in the upper vadose zone. The data collected with the various geophysical techniques should shed light on the applicability and effectiveness of each technique for detecting waste plumes below leaking tanks and disposal areas.

It was found that at present no vadose zone monitoring exists below waste disposal facilities in the 200 areas.

A.3 Recommendations:

- It is strongly recommended that all new waste disposal facilities in the 200 areas have horizontal plastic or metal pipes installed to provide access for vadose zone monitoring below the facilities. These pipes should serve as conduits for present (neutron moisture measurement) as well as future (geophysical and other methods) vadose zone monitoring.

- Consideration should be given to install a vadose zone leak detection system below all liquid effluent disposal facilities.

- It is recommended that DOE play a proactive role in vadose zone monitoring below all present and future waste disposal facilities to prevent groundwater contamination problems from occurring in the future.

Appendix B

April 25-27, 2001
MEETING AGENDA

BECHTEL BUILDING ASSEMBLY ROOM

WEDNESDAY, April 25		**Moderator**
7:30 – 8:00 (AM)	**On Your Own Coffee From Columbia River Coffee House**	
8:00 – 8:15	**Welcome and Introduction** **DOE-RL Welcome**	E Berkey K Klein
8:15 – 9:00	**Hanford Vision Update**	K Klein
9:00 – 9:30)	**IP : Making a Difference, Now and in the Future**	Ballard, Morse
9:30 - 10:00	**Open Discussion: Making a Difference, Now and in the Future**	All
10:00 – 10:15	**Break**	
10:15 – 12:30 (PM)	**IP: Status and Plans:** ♦ System Assessment Capability *(Bryce)* ♦ Characterization *(Knepp)* ♦ Science and Technology *(Freshley)* ♦ GW Remediation & Monitoring *(Mitchem)* ♦ System Characterization *(Ford)* ♦ Including 15 Minutes of Miscellaneous Items	Graham
12:30 – 1:00	**Lunch**	
1:00 – 2:30	**Stakeholders, Tribal Nations, and Regulators Input**	Points of Contact: IPEP: R Patt GW/VZ IP: M Jarayssi
2:30 – 3:45	**Panel Roundtable Discussion I**	Points of Contact: IPEP: E Berkey GW/VZ IP: M. Graham
3:45 – 4:00	**Break**	
4:00 - 5:00	**IPEP Internal Administrative Meeting**	
Evening	**Panel Only: Working Session #1**	

April 25-27, 2001
MEETING AGENDA (cont.)

BECHTEL BUILDING ASSEMBLY ROOM

THURSDAY, April 26		**Moderator**
7:30 – 8:00 (AM)	**On Your Own Coffee From Columbia River Coffee House**	
8:00 – 10:00	**Focus Session: SAC History Matching Results:**	Points of Contact: IPEP: R Bassett GW/VZ IP: R Bryce
10:00 – 10:15	**Break**	
10:15 – 12:15 (PM)	**Focus Session: Tank Farm Vadose Zone Characterization** • Review of Tank Farm Vadose Zone characterization approach (Harry Boston list) • What have we learned about S-SX tank farm? • Technical conclusions (interpretations of data and modeling) • Process, administrative conclusions (what will we do different or better next time) • Recommendations for S-SX interim actions and process improvements • Status of BX-102 field investigation • Summary of planned field investigation at T, TX-TY WMAs	Points of Contact: IPEP: J Conaway GW/VZ IP: A Knepp
12:15 – 12:45	**Break**	
12:45 – 2:15	**Focus Session: S&T S-SX Investigations** • Objective of S-SX S&T investigations • Approach to S&T investigations, including linkage to EMSP • Key findings of S&T investigations and linkage to FIR • Plans for BX-102 S&T investigation • Plans for T, TX-TY WMA investigation	Points of Contact: IPEP: J Matuszek GW/VZ IP: M Freshley
2:15 – 3:00	**Stakeholders, Tribal Nations, and Regulators Input**	
3:00 – 3:15	**Break**	
3:15 - 4:15	**Panel Roundtable Discussion II**	Points of Contact: IPEP: E Berkey GW/VZ IP: M Graham
4:15 – 5:30	**Panel Only: Working Session #2**	
Evening	**Panel Only: Working Session #3**	

April 25-27, 2001
MEETING AGENDA (cont.)

BECHTEL BUILDING ASSEMBLY ROOM

FRIDAY, October 27		**Moderator**
8:00 (AM) – 1:00 (PM)	**Panel Only: Working Session #4**	
	•	
1:00 – 2:00	**Closing remarks**	E Berkey/Panel
2:00 – 3:00	**Opportunity for Stakeholder, Tribal Nation, and Regulator Input and Comments**	E Berkey
3:00 – 4:00	**Panel Only: Wrap-up Session**	

Appendix C

HANFORD-RELATED EMSP RESEARCH PROGRAMS RELEVANT TO THE INTEGRATION PROJECT

EMSP projects focused on resolving the issue of ^{137}Cs mobility include:

Investigator	Organization	Title	Summary
Traina	Ohio State University	Immobilization of Radionuclides in the Vadose Zone Through Incorporation into Solid Phases	X-ray absorption spectroscopy (XAS) of chromium in S-SX Tank Farm sediments conducted at the APS and the Stanford Synchrotron Radiation Laboratory (SSRL), providing detailed understanding of the mobility of chromium contamination in the vadose zone affecting potential future contaminant transport Studying uranium speciation in sediments from leaked tank BX-102 by XAS
Zachara	Pacific Northwest National Laboratory	Fixation Mechanisms and Desorption Rates of Sorbed Cs in High Level Waste Contaminated Subsurface Sediments: Implications to Future Behavior and In-Ground Stability	Determined the mineralogic residence of cesium-137 in S-SX sediments and measurement/modeling of desorption rates
Flury	Washington State University	Colloid Facilitated Transport of Radionuclides Through the Vadose Zone	Determination of waste-sediment reaction products and their potential to expedite the transport of strongly sorbing cesium through the vadose zone

An additional EMSP project that is included in the investigation of the B-BX-BY tank farm include:

Investigator	Organization	Title	Summary
Jardine	Oak Ridge National Laboratory	Fate and Transport of Radionuclides Beneath the Hanford Tank Farms: Unraveling Coupled Geochemical and Hydrological Processes in the Vadose Zone	Column studies of uranium migration through undisturbed cores of 200-East Area sediments to support studies of the B-BX-BY tank farm

EMSP projects that are working to improve characterization of the vadose zone include:

Investigator	Organization	Title	Summary
Knight	University of British Columbia	The Use of Radar Methods to Determine Moisture Content in the Vadose Zone	Improving the usefulness of radar methods (ground-based and borehole) as a means of characterizing moisture content in the vadose zone Collaborating with Integration Project vadose zone transport field studies in radar image development for water content identification

Investigator	Organization	Title	Summary
Newman	Sandia National Laboratory	High Frequency Electromagnetic Impedence Imaging for Vadose Zone and Groundwater Characterization	Developing better ways to characterize the subsurface using magnetotelluric inversion codes Collaborating with the Integration Project in EMI method development for subsurface leak detection
Ward	Pacific Northwest National Laboratory	Rapid Migration of Radionuclides Under Salinity Gradients	Evaluating the impact of high salt concentrations on fluid migration in Hanford sediments Impacts evaluations of past and potential future tank leak plume migration This EMSP project has guided design of fluid injection experiments for vadose zone transport field studies conducted by the Integration Project

Other EMSP research projects that are linked to the Integration Project include:

Investigator	Organization	Title	Summary
Nagy	University of Colorado	Reactivity of Primary Soil Minerals and Secondary Precipitates Beneath Leaking Hanford Waste Tanks	Performing experiments with several generic tank waste simulants to develop an improved understanding of waste-sediment chemical reactions in the Hanford vadose zone Subsurface samples were provided to the investigator from 200 E and 200 W with the objective of defining a HLW-sediment geochemical reaction model applicable to multiple tank farms
Reeder	State University of New York at Stony Brook	Spectroscopic and Microscopic Characterization of Contaminant Uptake and Retention by Carbonates in Soils and Vadose Zone Sediments	Investigating the rates, mechanisms, and extent of uranium incorporation into calcium carbonate, a reactive mineral phase in the Hanford subsurface. Research results will assist in the interpretation and modeling of U transport behavior around leaked tank BX-102 and 200 Area Soil Sites that contain significant in-ground U inventories
Hess	Pacific Northwest National Laboratory	Technetium Attenuation in the Vadose Zone: Role of Mineral Interactions	Geochemical mineral surface mechanisms that may retard technetium migration in the Hanford subsurface are being studied. Mobile technetium is one of the primary risk drivers in the Hanford tank farms and selected crib areas
Buesseler	Woods Hole Oceanographic Institute	Speciation, Mobility, and Fate of Actinides in Groundwater at the Hanford Site	Low level actinide measurements are being performed in groundwaters up and downgradient of the major tank farms to determine if "trace" concentrations have migrated through the vadose zone
Meyer	Pacific Northwest National Laboratory	Quantifying Vadose Zone Flow and Transport Uncertainties Using a Unified, Hierarchical Approach	Developing and demonstrating a general approach for modeling flow and transport in a heterogeneous vadose zone in collaboration with Vadose Zone Transport Field Study
Murray	Pacific Northwest	Influence of Clastic Dikes on	Investigating the influence of clastic dikes on

Investigator	Organization	Title	Summary
	National Laboratory	Vertical Migration of Contaminants in the Vadose Zone	the vertical movement of moisture and contaminants through the vadose zone. New characterization techniques to be demonstrated in the project could be applied across the Hanford Site
Conrad	Sandia National Laboratory	Physics of DNAPL Migrations and Remediation in the Presence of Heterogeneities	Developing a fundamental quantitative understanding of the role of physical heterogeneities on DNAPL migration and remediation in aquifers.